Thesis/
Reports
Suchy,
W. J.
c. 1

EVALUATING THE EFFECT OF ROTATIONAL GRAZING ON BIRDS IN HIGH ALTITUDE SHRUBSTEPPE

Willie J. Suchy

EVALUATING THE EFFECT OF ROTATIONAL GRAZING ON BIRDS IN HIGH ALTITUDE SHRUBSTEPPE

by

Willie J. Suchy

Final Report

University of Wyoming Fish and Wildlife

Cooperative Research Unit

Laramie, Wyoming

Stanley H. Anderson, Leader

Agreement #28-C2-227

September, 1984

EVALUATING THE EFFECT OF ROTATIONAL GRAZING ON BIRDS IN HIGH ALTITUDE SHRUBSTEPPE

by

Willie J. Suchy

Final Report

University of Wyoming Fish and Wildlife

Cooperative Research Unit

Laramie, Wyoming

Stanley H. Anderson, Leader

ABSTRACT

Five potential avian survey techniques were evaluated for use in estimating bird densities. These included the variable-width strip transect, the variable-circular plot, the fixed-width strip transect, the point-center quarter and the closest object technique. The effect of rotational grazing on bird populations was also examined.

The five techniques were used to estimate the density of four bird species; the Mountain Bluebird, the Vesper Sparrow, the Green-tailed Towhee and the American Robin. Primarily based upon comparisons of the relative precision of the estimates, the first three techniques were judged to be suitable for similar high altitude, low density avian communities.

Comparisons of these density estimates showed that rotational grazing appears to have little affect on the bird species present on the Pole Mountain area. The available habitat of the area was chacacterized. Comparisons between the habitat characteristics of the three grazing periods were significantly different but this was not attributed to the effect of grazing. Bird observation sites were also characterized and comparisons with available habitat indicated that the birds were selecting for particular habitat variables. All of the comparisons involving habitat characteristics were complicated by the high degree of variability of the area's habitat.

TABLE OF CONTENTS

SECTION	PAGE
Introduction	1
CHAPTER 1	3
Study Area	7
Methods	8
Results	14
Discussion	17
CHAPTER 2	23
Methods	24
Results	25
Discussion	26
Conclusions	30
Literature Cited	34

ACKNOWLEDGMENTS

I would like to express much gratitude to those who helped with this project. This includes Dr. Stanley Anderson for his insight, advice and encouragment, Dr. Lyman McDonald for his guidance and help, to Craig Patterson, Cathy Raley and Theresa Wasserburger for their excellent help in the field and to the other members of the Coop Unit who provided many useful suggestions.

Funding for this project was provided in part, by the Rocky Mountain Forest and Range Experiment Station, U.S.D.A. Lorin Ward, Project Coordinator.

INTRODUCTION

The Pole Mountain area of the Medicine Bow National Forest is managed under the multiple use concept of management. Often this practice requires managers to balance many competing and conflicting uses of the land. The major uses of the Pole Mountain area currently include recreational activities as well as livestock grazing. Undoubtedly an important part of the recreational activities is the presence of wildlife species. Such recreational activities include consumptive uses such as hunting and fishing and non-consumptive uses such as photography, bird-watching, hiking, or camping. Because livestock and wildlife compete for many of the same resources, these uses are potentially conflicting.

Several studies (Ward 1973,1976, Ward and Cupal 1979) have investigated some of these areas of conflict. One area that has not been investigated is the potential conflict between birds and livestock. Studies in other grassland areas such as the Pawnee site in northern Colorado (Hyder et al. 1975, Ryder 1980), have documented the effects of heavy

grazing and its effect on bird populations. No study however, has investigated the effect of rotational grazing in an area similar to Pole Mountain. Thus, the goal of this study is to examine this area of potential conflict.

This study is divided into two parts. The first part uses five different survey techniques to estimate bird densities. These density estimates are examined to see if significant differences exist, either between the grazing periods or between the survey techniques. These techniques are then evaluated for use in other similar habitats.

The second part of this study examines habitat characteristics of the different grazing periods as well as those from bird observation sites to see if significant differences exist. The habitat characteristics are also summarized for the grazing periods and for the more numerous bird species. The data is also examined using discriminant analysis to look for meaningful relationships for each bird species.

CHAPTER 1. A COMPARISON OF FIVE SURVEY TECHNIQUES FOR BIRDS

Since most bird species are very mobile, estimates of abundance are often difficult to obtain. This is evidenced by the numerous techniques available to estimate avian densities. Although a complete census would often be desirable, time and funding constraints usually make it impossible. Thus most techniques used can be classified as sample surveys since they rely on samples to make inferences about the population.

The spot-mapping technique (Williams 1936, Kendeigh 1944, Robbins 1970) relies on mapping the singing males from numerous observations to deliniate territories on a study area. The number of territories is then converted to a density estimate. This method is considered by some to be a census since it can cover a complete habitat. A large amount of time and effort are required to collect the data using the spot-map technique. Several problems have been identified with this technique. They include variability in interpretation of mapped territories (Best 1975). Also,

territory sizes are poorly known for many species (Schoener 1968). The technique can also be used only during the very limited breeding season.

The remaining techniques rely on sample data. Sample plots may be surveyed for density, (Bond 1957, Anderson 1970) and the results extrapolated to a larger region, usually 100 hectares, using standard statistical techniques. Fixed-width strip transects (FST) can be classified as long rectangular sample plots (Burnham et al. 1980).

Variable-width strip transects (VST) (Emlen 1971, Eberhardt 1968, 1978, 1979, Burnham et al. 1980) rely on observed distances from a fixed transect line to estimate density. These observed distances are usually right angle distances but could be sighting distances and sighting angles. Burnham et al. (1980) provide a detailed explanation of methodology, derivations of density estimators and a computer program, TRANSECT, with which to analize data.

The major assumptions needed to use this technique are:

1. Objects directly on the line are always detected.
2. Objects are fixed at the initial sighting point.
3. Sightings are independent events.

The variable circular plot technique (VCP) (Reynolds et al. 1980, Ramsey and Scott 1979) uses timed counts at fixed points to estimate densities in much the same way as the VST technique. The observed distances are used to derive a "coefficient of detectability" or an "effective area" (Emlen 1971, Ramsey and Scott 1981). The assumptions needed for this technique are similar to those of the VST technique. Computer programs designed to estimate density with data collected by means of the VCP technique are not available. Thus most estimation procedures for VCP data are more subjective.

Plotless methods based on distances have also been proposed to estimate density (Eberhardt 1967). Although these techniques have not been widely used for bird surveys, two seem particularly applicable. The point-center quarter technique (PCQ) uses the distance to the closest object in each of four quarters to estimate density. The closest object technique (CO) uses the distance to the closest object to estimate density.

Recently studies have been conducted to evaluate the more widely used avian sampling techniques. Franzreb (1976, 1981a, 1981b) compared the spot-mapping technique with the VST in a mixed coniferous forest in Arizona. Edwards et al. (1981) compared the sample plot, VST and VCP techniques

along the Columbia River in Oregon. DeSante (1981) compared the results obtained with the VCP technique against an intensive program of color-banding, spot-mapping and nest monitoring in a California coastal scrub community. Anderson and Ohmart (1981) compared VCP and VST techniques along the Colorado River near the Arizona - California border. O'Meara (1981) compared spot-mapping with VST in pine slash in north-central Florida. Redmond et al. (1981) compared spot-mapping and VST techniques for Long-billed Curlews (Numenius americanus)in Idaho. The results of these studies make it apparent that the effectiveness of these techniques varies depending upon the particular application and habitat.

In this chapter I will evaluate five avian survey techniques; FST, VST, VCP, PCQ, and CO, for their effectiveness in a high altitude shrubsteppe community. The null hypothesis that no difference exists between the density estimates resulting from the five techniques will be tested.

The specific objectives of this study are:

1. Use the five techniques to estimate the density of birds occuring in a high altitude shrubsteppe grassland.
2. Examine and compare the resulting density estimates

and their associated variability to see if significant differences exist.

3. Make recommendations based on these comparisons for use of these avian survey techniques in other similar high altitude grassland communities.

STUDY AREA

The Pole Mountain area of the Medicine Bow National Forest was used as the study area. It is located approimately 18 km east of Laramie, Wyoming. The area consists of rolling hills ranging in elevation from 2000 to 2750 meters. The vegetation consists of open grassland, scattered shrub with areas of dense sagebrush (Artemisia sp.), scattered trees and small dense forests. Tree species present included ponderosa pine (Pinus ponderosa), limber pine (Pinus flexilis), lodgepole pine (Pinus contorta), aspen (Populus tremuloides) and willows (Salix sp.).

Historical uses of the Pole Mountain area include livestock grazing, military training area, and recreation. Since becoming National Forest land, the main uses have become recreation and grazing. Currently there are seven different grazing allotments, each consisting of two, three

or four seperate pastures (See Figure 1). Six of the allotments are grazed by cattle and one is grazed by sheep. Grazing normally begins in early June. The cattle are then rotated between the pastures of an allotment during the summer. In each allotment one pasture is grazed from early June to early July, one pasture is grazed from early July to early August and one or two pastures are grazed from early August through late September or early October. For the purposes of this study the pastures grazed first will be refered to as the early grazed pastures, those grazed second, the middle grazed pastures and those grazed last, the late grazed pastures. The actual time that cattle are moved between the pastures depends upon many factors such as the actual weather, road and pasture conditions. The grazing cycle is set each spring by Forest Service personnel. In 1983 the grazing schedule was delayed more than two weeks due to an exceptionally heavy snowpack.

METHODS

Thirty eight sites were selected which were suitable for 1000 meter long transects. These are shown on Figure 1. All of the transects were located in pastures grazed by cattle. In 1982, 12 transects were located in early grazed,

eight in middle grazed and 12 in late grazed pastures. In 1983, fourteen transects were located in early grazed pastures, ten in middle grazed pastures and ten in the late grazed pastures.

The early grazed pastures selected in 1982 were Beacon #3, Crow Creek #1, Green Mountain #3, Horse Creek #2, Lodgepole #2 and North Pasture #3. In 1983, Beacon #4, Green Mountain #4, Lodgepole #1 and North Pasture #1 were selected. Four transects were established in Beacon #4 and Crow Creek #2 while two transects were located in the rest. This uneven weighting was done because it was assumed that the impact of grazing on the birds would be greatest during the breeding season. These early grazed pastures also were big enough to allow extra transects. This set of pastures had cattle on them from mid June to mid July.

The middle grazed pastures selected in 1982 were Beacon #4, Crow Creek #2, Green Mountain #4 and Lodgepole #2. In 1983, Beacon #2, Crow Creek #3, Horse Creek #2, Lodgepole #2 and North Pasture #2 were selected. Two transects were established in each pasture. Cattle were present from the middle of July to mid August.

The late grazed pastures selected in 1982 were Beacon #2, Crow Creek #3, Green Mountain #2, Horse Creek #3, Lodgepole #1 and North Pasture #2. In 1983, Beacon #3, Crow

Creek #3, Green Mountain #2, Horse Creek #2 and Lodgepole #3 were selected. Two transects were established in each pasture. Cattle were present begining in late August.

Transects were marked at each selected site by placing one meter long lathe stakes in the ground every 100 meters for a total of 1000 meters. Riparian areas and densely forested ares were avoided. Care was taken to avoid potentially biasing the transects. This was done by locating them so as not to follow geographic or topographic features such as ridge tops or valleys.

These transects were then used to collect data for the transect survey techniques (VST and FST) in 1982 and 1983. Data was collected for both techniques simultaneously.

Observaion points for the point survey techniques (CO, PCQ, and VCP) were established on 34 of the transects in 1983. Four points were chosen on each transect. This was done by randomly choosing either the 100, 200 or 300 meter stake as the first observation point and making every other stake after that an obsevation point. This insured that 200 meters seperated the observation points to help assure that they are independent. Thus if the 100 meter stake was selected as the first observation point, then the 300, 500 and 700 meter stakes would also be observation points. Once these points were selected they were used for all three

point surveys techniques.

Transect surveys were done once every 14 days beginning 1 June 1982 and 2 June 1983. Point surveys were done once every 20 days begining 6 June 1983. All transects were surveyed a total of five times. All points were surveyed a total of four times. All surveys were conducted from one half hour after sunrise to 1000 hours. Normally four transects or 16 points could be surveyed during a morning by one person. Point surveys and transect surveys were never run on the same pasture on the same day. Although this may have been desirable, Scott and Ramsey (1981a) and Scott et al. (1981b) found that this could yield biased results due to disturbances caused by the observer.

Data were collected from the transects by walking their length and recording the right angle distance to each bird observed. The bird was identified and the species recorded as well as its age, sex and activity when sighted. The weather conditions at the time, the date, the time as well as several habitat variables were also recorded. Fifty meters was choosen as the limit at which birds could readily be identified. This distance is arbitrary (Burnham et al. 1980). The right angle distances to the observations were usually paced from the centerline.

Data were collected from the points by walking along the

transect to the observation point. Once the observer was at the point, they waited one minute for the birds to settle down and then recorded all sightings for the next six minutes. Six minutes was choosen based on the results of a preliminary study where the observer waited 15 minutes at each point and recorded the time to first sighting for all birds seen (See Figure 2). The same data were gathered for each bird observed from the points as was gathered for birds on the transects. Additionally the compass direction to the bird in degrees was also recorded.

These survey techniques treat the observations as if they were gathered instantaneously. Since each technique actually requires a small amount of time, field conventions were established to meet the assumptions behind the techniques. First, birds flying over the area were not counted unless they were hunting for food (Anderson et al. 1979). Secondly, if birds were flushed incidentily, such as when walking to the observation point, the bird's location was noted. Judgement was then used to determine if the bird would have been seen from the point or transect. An example of when a bird might not have been seen would be a female on a nest some distance away. These conventions should help eliminate the problem of changing the probability of sighting a bird during the survey.

The surveys resulted in two sets of data, one from the transect surveys and one from the point surveys. Data were keypunched and entered onto computer files. These files were then verified against the field forms.

Density estimates for the FST technique were calculated directly from the data. Variances were calculated by treating the transects as random sample plots.

The program TRANSECT was used to calculate the density and variance estimates for the VST technique. This was done by entering the individual right angle distances, the birds seen and the transect length for each transect. The program TRANSECT was also used to calculate density and variance estimates for the VCP technique. This was done by converting distances to areas and then entering these areas the number of observation points in place of the transect lengths and the number of birds seen (Burnham et al. 1980:195).

A computer program, BOOT, was written to estimate the density and variances for the PCQ and CO techniques. Density was estimated using formulas from Eberhardt (1967). Bootstrapping was used to estimate the variances for these techniques (Efron 1981).

For all five techniques, estimates were made for each

grazing period. The data was then combined to give overall "average" density estimates. Species were included that had 40 or more observations (Anderson et al. 1979).

Comparisons between the techniques will be based primarilly upon the precision of the overall density estimates. Precision is used rather than accuracy because there is no measure of absolute density available (Tilghman et al. 1981). T-tests were used to determine if statistically significant differences exist between the density estimates for the grazing periods for the various species. T-tests were also used to determine if significant differences exist between the density estimates from the five techniques themselves. T-tests assummed that the variances between the samples were uneqaul (Sokal and Rohlf 1969). Additionally, each technique will be reviewed for such things as potential for biases, standardization procedures needed to use the technique when recommendations are made.

RESULTS

Table 1 lists the numbers of individuals in each species observed on the transect and point area surveys. Other

species observed while doing the transect surveys in 1982 and 1983 included the Brown-headed Cowbird (Molothrus ater), Rock Wren (Salpinctes obsoletus), American Goldfinch (Caduelis tristis), House Finch (Carpodacus mexicanus), Flycatcher (Epidonax sp.), Western Wood-pewee (Contopus sordidulus), Red-headed Woodpecker (Melanerpes erythrocephalus), Mallard (Anas platyrhychos), Veery (Catharus fuscescens), Yellow Warbler (Dendroica petechia), White-breasted Nuthatch (Sitta carolinensis), Red-breasted Nuthatch (Sitta canadensis), Downy Woodpecker (Picoides pubescens), Hairy Woodpecker (Picoides villosus), McCown's Longspur (Calcarius mccownii), Pine Siskin (Carduelis spinus), Cassin's Finch (Carpodacus cassinii), Great Horned Owl (Bubo virginianus), Prarie Falcon (Falco mexicanus), and the Red-tailed Hawk (Buteo jamaicensis). In addition to the species listed in Table 1 a Red-tailed Hawk was observed while doing the point surveys.

Three species, the Mountain Bluebird, the Vesper Sparrow and the Green-tailed Towhee, had adequate sample sizes for all survey techniques. The American Robin and the Common Grackle had marginally adequate sample sizes. The American Robin was included in further analyses because it was present on most transects and points. The Common Grackle was excluded because most of the point survey observations occured at one point when one large flock was sighted.

Table 2 lists the density estimates and standard errors calculated for each of these four species for each of the five survey technques. Estmates were made for each grazing period and for all grazing periods combined. The periods were combined because the t-tests showed no significant differences at the 99 percent confidence level and only two significant difference at the 95 percent confidence level. The significant differences were for the Mountain Bluebird between the early and middle grazed pastures in 1982 for the VST technique and for the Vesper Sparrow between the early and late grazed pastures for the FST technique in 1983. Also by combining data for the three grazing periods, estimates with larger sample sizes can be used for comparisons. This should reduce the effect that sampling error has on the results. Direct comparisons between the results for the five techniques will be limited to 1983, since point survey data were not collected in 1982. Table 3 lists the coefficients of variation for these combined estimates.

Figure 3 through Figure 6 graphically illustrate the different density estimates resulting from the five techniques. Those estimates which were statistically different are also indicated.

Figure 7 and Figure 8 are histograms of the number of

mountain Bluebirds observed on the late grazed pastures. Figure 7 represents observations on the point surveys while Figure 8 represents observations on the transect surveys. These were taken directly from the output of TRANSECT.

DISCUSSION

From Table 1 it is apparent that many more individual birds were observed during the transect surveys. It is important to remember two things when looking at these numbers. First, the transects were surveyed five times while the points were only surveyed four times. Secondly, the point surveys covered about 25 percent more total area than the transect surveys. This is true since four points with a maximum distance searched of 100 meters covers about 125,664 square meters while a 1000 meter transect with a maximum distance searched of 50 meters covers only 100,000 square meters. With this in mind, the relative effectiveness (the number of individual birds seen per area per time) of the transect surveys was over 170 percent better than the point surveys.

The transect surveys resulted in 10 more species being detected than did the point surveys. This is contrary to

what Edwards et al. (1981) found but supports Anderson and Ohmart's (1981) findings. Although the study results are similar to those of Anderson and Ohmart (1981) their reasoning is not supported by this study. They attributed the difference in their results to the difference in areas sampled. Here I believe the difference is due to the fact that more diverse habitats were sampled with the transects. Evidence for this was the difficulty encountered in locating the transects in similar areas in each pasture. Also the points, since they are not contiguous, can more easily be located in homogenious areas. Thus, point surveys could be an advantage if a particular habitat to be surveyed was not large enough for transects.

The time and effort involved in gathering data for the transect surveys and the point surveys was comparible. This is supported by the fact that all points could be surveyed in about the same time that all transects could be surveyed. Thus time requirements do not seem to be a critcal factor when low density populations are surveyed. This could change however, if the detection time increases for the point surveys when density increaases.

From the density estimates in Table 2 we see that there is no significant difference in the density estimates for the different grazing periods. In fact, no patterns are

suggested. This might indicate several things. First grazing does not effect the common species of the area. This may be true if the common species are generalists and are able to adapt quickly to changing habitat conditions. Also due to the above normal snowpack during the winter of 1982-3 and the fact that cattle grazing was delayed by about two weeks, the effect of grazing might have been decreasesd. Finally, it is possible that the survey techniques are unable to detect subtle differences that might exist. Thus, even if differences did exist they could be swamped by sampling error. If this were true we would not expect to see any significant differences or patterns among the five survey techniques.

This is not the case however, as we see from Figures 3, 4, 5 and 6. The graphs of the density estimates for these four species exhibit similar patterns between the techniques. For all four species, we see that the CO and PCQ are very low and close together. We also see that the VCP and VST estimates are highest and close to each other. The FST estimates are consistently between these two groups. Some of these estimates differ significantly. This is mostly true of the CO and PCQ estimates which are significantly different from the VCP and VST estimates for three of the four species.

The estimates for the Mountain Bluebird, Figure 3, probably best illustrates the above pattern. This is to be expected since it has the largest sample sizes. This is also the only species where zero is more than one standard error from the means of the CO and PCQ techniques. Again, probably the result of the larger sample sizes.

For the Vesper Sparrow, Figure 4, we see the same pattern. However, here the VST and the FST estimates are also significantly different. The thing to note here is that the small standard error for the VST estimate makes it easier to detect actual differences.

Looking at Figures 5 and 6 we see the same patterns but the difference between the estimates is not significant in all cases. This is probably due to the fact that the sample sizes are smaller and sample error could become more of a factor.

The pattern seen is consistent with the theoretical principles of the five techniques. The CO and PCQ techniques both rely on randomly sampled distances to estimate density. These techniques probably both yielded low estimates in relation to the others because too many of the points had no observations for a species. This resulted in many points where the maximum area was searched but no birds were found. This then lowers the density estimates.

The VCP and VST techniques both use sighting functions to estimate densities. Thus, if all of the birds present are not detected, the density estimates are adjusted to account for this fact. Figure 7 and Figure 8 both suggest that the probability of detecting a bird decreases as distance increases. The program TRANSECT was used to analize the data for both techniques. The Fourier estimator from the program was found to be applicable for both techniques (Burnham et al. 1981). Since each technique used different data sets, the fact that both estimates are fairly close to each other for all four species is a reflection on the robustness of the TRANSECT program. This is a very desirable characteristic.

The FST estimates are lower than the VCP and VST estimates because it appears that some birds were missed and this technique relies on a complete census of the area for accurate results. The FST estimates are higher than the CO AND PCQ estimates because the transect surveys had more observations and less plots where no birds were observed. This difference would probably not be evident if the techniques were used in areas with higher densities.

Lastly, if we look at the relative precision of the five estimates, the VST and VCP estimates have the lowest coefficients of variation (Table 3.). Since TRANSECT was

used for both the VST and VCP techniques, the differences in the precision of these estimates may be due in part to the differences in the number of birds observed.

CHAPTER 2. HABITAT ANALYSIS

Habitat selection by birds in grasslands seems to be more generalized than that described for other communities (Hilden 1965, Wiens 1969, Cody 1968, Wiens and Rotenberry 1981). This is likely due to the fact that vegetation structure known to be important to avian communities (MacArthur and MacArthur 1961, Anderson and Shugart 1974) appears to be less distinct in grasslands.

However, since grazing has been known to alter the community structure, change the plant species composition as well as change the soils and soil moisture (Ryder 1980), it must be evaluated for its impact on bird species. Thus the specific objectives of this chapter are to:

1. Characterize available habitat for the Pole Mountain area.
2. Characterize the habitat where birds were observered and determine what parameters the birds are selecting.
3. Identify important habitat parameters for the bird

species observed.

The hypothesis that will be tested is that no differences exist between the habitat characteristics of the three grazing periods due to the influence of grazing.

METHODS

Seventeen variables were picked to describe the habitat. These included; percent total cover, percent grassy cover, percent forb cover, percent bare ground, biomass of the vegetation, canopy cover, aspect, litter depth, percent litter cover, and the distances to the nearest water (riparian area), road, wire, pole, structure (rock, log, stump, etc.), tree and perch (tree, shrub, rock, etc.).

Percent cover was estimated using a modified "point frame" (Hays et al. 1981). Biomass was estimated using a pole marked into 5 cm sections (Robel et al. 1970). (No attempt was made to correlate actual biomass present with measurements. Thus this measurement was an index of biomass.) The aspect was determined from a compass. Litter depth was measured and percent litter cover was estimated visually. Distance measurements were estimated visually.

Values for these variables were recorded at the point

where each bird was sighted. Additionally, 40 random points were selected on each transect each year. Twenty were selected in June and 20 in July and values were recorded for the habitat variables for each point.

Analysis of the data consisted of preliminary examination for normality and the calculation of summary statistics. The random points and 22 bird species (all species with more than five sightings) were analized. Comparisons were made between the random points in the three grazing periods to see if significant differences existed. Comparisons were also made between the random points and the bird observation points to see if significant differences existed. Only bird species with more than 40 sightings were included (Green 1979). A discriminant analysis was also preformed on these species to identify important variables. All analyses were done using SPSS programs.

RESULTS

Table 4 lists the means and standard deviations for the random points and for the 22 bird species. Those variables that were significantly different based on the Kruskal-Wallis (K-W) Anova test (Steel and Torre 1980) at the ($p = .05$) level are also indicated. A non-parametric test was used for all comparisons because some of the habitat

variable distributions appeared to be non-normal (values of kurtosis and skewness were high).

The structure coefficients, canonical correlation and classification scores from the discriminant analysis are listed in Table 5 for the 10 bird species with adequate sample sizes. The discriminant analysis was preformed using only nine of the original 17 habitat variables. This was done to eliminate linear combinations of variables and to include only the more significant variables. Discriminant analysis was used even though some of the remaining habitat variables were still non-normal (Green 1979).

Appendix A contains complete summary statistics for the random points. These are broken down by grazing period for each year. Appendix B contains the complete summary statistics for the 22 bird species. These are broken down by bird for each grazing period each year.

DISCUSSION

The first thing apparent from Table 4 is that the habitat variables contain high variability. The coeficients of variation for the random points range from 39 to 261 percent. Thus it is somewhat suprising that when the three grazing periods are tested using the K-W Anova that 12 of

the 17 habitat variables exhibit differences that are statistically significant. This indicates that differences did exist between the transects in the different grazing periods. Although these differences could be due to the impact of the rotational grazing, it seems more likely that the transects themselves were different. Looking at Appendix A, we see that many of the variables that have the smallest mean for one grazing period in 1982 have a mean that is smaller for a different grazing period in 1983. This lack of consistency between the years supports the idea that the transects differ, otherwise we would expect the grazing periods to show consistent patterns due to the effect of grazing. For example, we would expect the mean of a variable to be smallest for the same grazing period for both years if grazing was the controlling factor.

Because no grazing effects were clearly apparent, either from the bird densities or from the habitat analysis, all random points were combined for the comparisons with the bird species. This pooling also helps reduce the variation of the random habitat points.

Looking at Table 4 we see that the values for the habitat variables for the 22 bird species are also quite variable and are nearly always within one standard deviation of the means for the random points. Even the Mountain

Bluebird, the species with the largest sample size, has coefficients of variation ranging from 37 to 342 percent.

For the 10 species that had large enough sample sizes to be compared statistically using the K-W Anova test,we see some interesting things. First, the proximity to roads, wires, poles and water did not generally differ from random. Thus it appears that birds were not affected by these factors. Secondly, we see that no two birds differed from the random points on exactly the same habitat variables. This suggests that birds were observed in characteristically different places. Since these comparisons only suggest that differences do exist but not what they are or mean, it is neccessary to do further analysis to characterize the observation sites for these species.

Discriminant analysis was preformed for each bird species seperatly comparing its observation sites with the random sites. From the results in Table 5, the first thing we notice is that the discriminant functions have small canonical correlations. This indicates that the discriminating power of the data is low. Only the canonical correlation for the Green-tailed Towhee was very large. It indicated that the discriminant function explained about 67 percent of the variation in the data. The next largest was for the Brewer Sparrow which had a canonical correlation of

.2706 . Thus, the discriminant function only explained about 50 percent of the variation in the data. This is considered to be small (Klecka 1982), especially when we consider the fact that we have violated the assumption of multivariate normality basic to this technique. Thus, any conclusions based upon these analyses should be viewed cautiously. Statistical tests and criteria will also not be examined during the rest of these analyses since they are probably biased or inaccurate (Klecka 1982).

We can, tentively look at the relationships between the variables to see if they make sense (Green 1979, Klecka 1982). This we can do by looking at the structure coefficients listed for each species in Table 5. Meaningful contributions to the discriminant function are made when a variable or set of variables has a relatively high value for that structure coefficient. These can then be viewed as "discriminating variables" and should characterize important habitat components.

It appears that for the Mountain Bluebird, the American Robin, the House Wren, the Nortern Flicker and the Dark-eyed Junco that litter cover and litter depth are the best discriminating variables. For the Green-tailed Towhee, the Vesper Sparrow and the Brewer Sparrow it appears that litter cover, litter depth, brush cover and biomass are the best

discriminating variables. The Horned Lark is best discriminated by a negative relationship with distance to structure and trees. The Common Grackle does not appear to have any good discriminating variables.

Stepwise discriminant analysis based upon F values (Klecka 1982), points out that some variables may contain the same information (are highly correlated), since the discriminating variables changed between the analysis (Klecka 1982). Split-half discriminant analysis (Klecka 1982) was also preformed which resulted in different discriminating variables. These results, the fact that the canonical correlations were low and the fact that the classification scores were lower than if we just classified everything as random, again points out that we should view this analysis with extreme caution.

CONCLUSIONS

Based upon these results we can conclude that the rotational grazing system does not appear to affect the densities of birds on the Pole Mountain area. This may be due to the type bird that inhabits the area since they may be of the "generalist" type. This may also be due to the

fact that the existing habitat on the pastures is quite variable.

We can reject the null hypothesis of Chapter 1. There does appear to be significant differences between the five survey techniques. Thus, we should review the effectiveness of the five techniques to estimate the density of birds based on the relative precision of the estimates, possible biases of the techniques and the standardization procedures needed to use the techniques.

The VST technique is probably best for estimating bird densities in a high altitude shrubsteppe community. It yielded estimates with the lowest coefficients of variation for the five survey techniques. This was probably due to the increased relative efficiency of the transect surveys since many more individual birds were observed.

The VCP technique yielded density estimates that were very close to the VST estmates and were only slightly less precise, again probably due to the fact that the total number of birds observed was lower.

For both techniques it is important that all birds on the transect line or point are detected. It is also important that distances are measured accurately. These are potential bias for both techniques. It is also recommended

that the program TRANSECT be used to estimate densities for both techniques as it appears to be robust.

Deciding between the two techniques can probably be done on the basis of the goal of the survey and the habitat to be surveyed. If small areas or areas in rough terrain are to be surveyed then the VCP technique may be better suited. Otherwise the VST technique would probably yield more precise results. If the VCP technique is to be used the time an observer must wait at an observation point should be checked and possibly recalibrated.

If access to a computer or the program TRANSECT is limited then the FST technique would be the next choice. This technique should result in fair to marginal precision. Little standardization is required for the technique other than for small areas where the transects (sample plots) could be reduced in size. The potential bias for this technique is that all the birds in an area may not be seen. This would result in an underestimate of density.

Lastly, the CO and PCQ techniques do not seem to be suitable for such low density habitats. The precision is very low and the number of points that have no observations may bias the density estimates downward.

Although statistical differences were found in the

habitat characteristics of the transects in the different grazing periods, it seems doubtful that these differences are due to the effects of grazing. Thus we cannot reject our null hypothesis for Chapter 2. This conclusion is supported by the lack of consistent patterns in the data and the fact that the data contains large amounts of variation. This variation complicates further analysis since it reduces the discriminating power of multivariate techniques.

The habitat characteristics of the observation sites for the 22 bird species examined were summarized using univariate statistics. Further meaningful analysis was inhibited by the large degree of variability in the data. It should also be noted that this data only characterizes observation sites and not use, since it is clear from Chapter 1 that not all birds were being seen on an area. Thus these observation sites are biased and are not a random sample of occupied habitat.

LITERATURE CITED

Anderson,B.W. and R.D. Ohmart. 1981. Comparisons of avian census results using variable distance transect and variable circular plot techniques. Pp. 186-192 in C.J.Ralph and J.M. Scott (eds.). Estimating the numbers of terrestrial birds. Stud. Avian Biol. No. 6.

Anderson,D.R., J.L. Laake, B.R. Crain and B.R. Burnham. 1979. Guidelines for line transect sampling of biological populations. J. Wildl. Manage. 43:70-78.

Anderson,S.H. 1970. The avifaunal composition of Oregon white oak stands. Condor 72:417-423.

---- and H.H. Shugart, Jr. 1974. Habitat selection of breeding birds in an east Tennessee deciduous forest. Ecology 55:828-837.

Best,L.B. 1975. Interpretational errors in the "mapping method" as a census technique. Auk 92:452-460.

Bond,R.R. 1957. Ecological distribution of breeding birds in upland forests of southern Wisconsin. Ecol. Monogr. 27:351-384.

Burnham,K.P.,D.R. Anderson and J.L. Laake. 1980. Estimation of density from line transect sampling of biological populations. Wildl. Monogr. 72.

---- 1981. Line transect estimation of bird population density using a Fourier series. Pp.466-482 in C.J.Ralph and J.M. Scott (eds.). Estimating the numbers of terrestrial birds. Stud. Avian Biol. No. 6.

Cody. M.L. 1968. On the methods of resource division in grassland bird communities. Am. Nat. 102:107-147.

Desante,D.F. 1981. A field test of the variable circular-plot censusing technique in a California coastal scrub breeding bird community. Pp. 177-185 in C.J.Ralph and J.M. Scott (eds.). Estimating the numbers of terrestrial birds. Stud. Avian Biol. No. 6.

Eberhardt,L.L. 1967. Some developments in distance sampling. Biometrics. 23:207-216.

---- 1968. A preliminary appraisal of line transects. J. Wildl. Manage. 32:82-88.

---- 1978. Transect methods for population studies. J. Wildl. Mange. 42:1-31.

---- 1979. Line transects based on right angle distances. J. Wildl. Manage. 43:768-774.

Edwards,D.K., G.L. Dorsey and J.A. Crawford. 1981. A comparison of three avian cesus methods. Pp in C.J.Ralph and J.M. Scott (eds.). Estimating the numbers of terrestrial birds. Stud. Avian Biol. No. 6.

Efron,B. 1982. The jackknife, the bootstrap and other resampling plans. Soc. for Industrial and Applied Mathematics. Philadelphia, Penn.

Emlen, J.T. 1971. Population densities of birds derived from transect counts. Auk 88:323-342.

Franzreb, K.E. 1976. Comparison of variable strip transect and spot-map methods for censusing avian populations in a mixed coniferous forest. Condor 78:260-262.

---- 1981a. The determination of avian densities using the variable-strip and fixed-width transect surveying methods. Pp. 139-145 in C.J.Ralph and J.M. Scott (eds.). Estimating the numbers of terrestrial birds. Stud. Avian Biol. No. 6.

---- 1981b. A comparitive analysis of territorial mapping and variable-strip transect censusing methods. Pp. 164-169 in C.J.Ralph and J.M. Scott (eds.). Estimating the numbers of terrestrial birds. Stud. Avian Biol. No. 6.

Green,R.H. 1979. Sampling design and statistical methods for environmental biologists. John Wiley and Sons, New York. 257 pp.

Hays,R.L., C. Summers and W. Seitz. 1981. Estimating wildlife habitat variables. U.S.D.I. Fish and Wildlife Service. FWS/OBS-81/47. 111 pp.

Hilden, O. 1965. Habitat selection in birds: a review.

Ann. Zool. Fenn. 2:53-75.

Hyder, D.N., R.E. Bement, E.E. Remmenga, and D.F. Hervey. 1975. Ecological responses of native plants and guidlines for management of shortgrass range. USDA Tech. Bull. 1503:1-87.

Kendeigh,S.C. 1944. Measurments of bird populations. Ecol. Monogr. 14:67-106.

Klecka, W.R. 1982. Discriminant analysis. Sage University paper series, quantitative applications in the social sciences. Series no. 19. Sage Publications, London. 71 pp.

MacArthur, R.H. and J.W. MacArthur. 1961. On bird species diversity. Ecology 50:594-598.

O'Meara,T.E. 1981. A field test for two density estimators for transect data. Pp. 193-196 in C.J.Ralph and J.M. Scott (eds.). Estimating the numbers of terrestrial birds. Stud. Avian Biol. No. 6.

Ramsey,F.L. and J.M. Scott. 1979. Estimating population data from variable circular plot surveys. Pp. 155-181 in R.M. Cormack, G.P. Patil and D.S. Robson (eds.). Sampling biological populations. Stat. Ecol. Ser., vol. 5. Int. Co-op. Publ. House, Fairland, Md.

---- 1981. Analysis of bird survey data using a modification of Emlen's method. Pp. 483-487 in C.J.Ralph and J.M. Scott (eds.). Estimating the numbers of terrestrial birds. Stud. Avian Biol. No. 6.

Redmond,R.L., T.K. Bicak and D.A. Jenni. 1981. An evaluation of breeding season census techniques for Long-billed Curlews (Numenius americanus). Pp. 197-201 in C.J.Ralph and J.M. Scott (eds.). Estimating the numbers of terrestrial birds. Stud. Avian Biol. No. 6.

Reynolds,R.T., J.M. Scott and R.A. Nussbaum. 1980. A variable circular-plot method for estimating bird numbers. Condor 82:309-313.

Robbins,C.S. 1970. Recommendations for an international standard for a mapping method in bird census work. Aud. Field Notes. 24:723-726.

Robel, R.J., J.N. Briggs, A.D. Dayton, and L.C. Hubert. 1970. Relationship between visual obstruction measurements and weight of grassland vegatation. J. Range Mange. 23:295-297.

Ryder, R.A. 1980. Grassland management practices and bird communities. IN Workshop Proceedings, Management of western forests and grasslands for nongame birds. R.M. DeGraaf and N.G. Tillman eds. USDA Forest Service GTR-INT-86. pp 51-66.

Schoener, T.W. 1968. Size of feeding territories among birds. Ecology 49:123-141.

Scott,J.M. and F.L. Ramsey. 1981a. Length of count period as apossible source of bias in estimating bird numbers. Pp. 409-413 in C.J.Ralph and J.M. Scott (eds.). Estimating the numbers of terrestrial birds. Stud. Avian Biol. No. 6.

Scott, J.M., F.L. Ramsey and C.B. Kepler. 1981b. Distance estimation as a variable in estimating bird numbers. Pp. 334-340 in C.J.Ralph and J.M. Scott (eds.). Estimating the numbers of terrestrial birds. Stud. Avian Biol. No. 6.

Sokal, R.R. and F.J. Rohlf. 1969. Biometry: the principles and practices of statistics in biological research. Freeman, San Francisco.

Steel, R.G.D. and J.H. Torrie. 1980. Principals and procedures of statistics: a biometrical approach. Second edition. Mcgraw Hill Book Co., New York. 633pp.

Tilghman, N.G. and D.H. Rusch. 1981. Comparison of line-transect methods for estimating breeding bird densities in deciduous woodlots. Pp. 202-208 in C.J.Ralph and J.M. Scott (eds.). Estimating the numbers of terrestrial birds. Stud. Avian Biol. No. 6.

Ward, A.L. 1973. Elk behavior in relation to multiple uses of the Medicine Bow National Forest. Proc. West. Assoc. State Game and Fish Comm. 53:125-141.

---- 1976. Elk behavior in relation to timber harvest operartions and traffic on the Medicine Bow range in south-central Wyoming. IN Proc. Elk-Logging-Roads Symp. ed. S.R. Heib, Pp. 32-43. Univ. Idaho, Moscow. 142 pp.

---- and J.J. Cupal. 1979. Telemetered heart rate of three elk as affected by activity and human disturbance. IN Dispersed Recreation and Natural Resource Management, Pp. 47-56. Symp. Proc. Utah State Univ., Logan.

Wiens, J.A. 1969. An approach to the study of ecological relationships among grassland birds. Ornith. Monogr. 8:1-93.

---- and L.T. Rottenberry. 1981. Habitat associations and community structure of birds in shrub-steppe environments. Ecol. Monogr. 51:21-41.

Williams, A.B. 1936. The composition and dynamics of a beech-maple climax community. Ecol. Monogr. 6:317-409.

Table 1. The numbers of individuals of each species observed on transect and point area surveys.

Species	1982 Transect Numbers	1982 Rank	1983 Transect Numbers	1983 Transect Rank	1983 Point Area Numbers	1983 Point Area Rank
Mountain Bluebird (Sialia curricoides)	187	1	221	1	75	1
Vesper Sparrow (Pooecetes graminus)	107	3	126	2	47	3
American Robin (Turdis migratoris)	80	4	97	3	28	5
Green-tailed Towhee (Pipilo chlorurus)	142	2	88	4	41	4
Brewer's Blackbird (Euphagus cyanocephalus)	67	7	65	5	5	9
Chipping Sparrow (Spizella passerina)	32	11	59	6	14	6
Dark-eyed Junco (Junco hyemalis)	49	8	38	7	5	9
Common Grackle (Quiscalus quiscula)	70	6	36	8	69	2
Horned Lark (Eremophila alpestris)	48	9	35	9	10	7
Northern Flicker (Colaptes auratus)	24	12	29	10	8	8
Brewer's Sparrow (Spizella breweri)	78	5	28	11	14	6
House Wren (Troglodytes aedon)	41	10	23	12	4	11
Mountain Chicadee (Parus gambeli)	8	15	6	13	1	18
Clark's Nutcracker (Nucifragra leucophyrus)	4	16	6	13	4	11
White-crowned Sparrow (Zonotrichia leucophyrus)	17	13	5	15	2	15
Song Sparrow (Melospiza melodia)	12	14	5	15	2	15
Killdeer (Charadrius vociferus)	1	19	4	17	3	14
Tree Swallow (Tachycineta bicolor)	3	17	3	18	2	15
American Kestrel (Falco sparverius)	1	19	2	19	1	18
Townsend's Solitaire (Myadestes townsendi)	2	18	1	20	1	18
Broad-tailed Hummingbird (Selasphorus platycercus)	4	16	1	20	4	11
Others	60		10		1	
Total	1037		888		341	

Table 2. The density and standard error estimates from the five avian survey techniques (density measured in numbers per hectare).

		1982				1983									
		VST		FST		CO		PCQ		VCP		VST		FST	
Species	Grazing Period	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
Mountain Bluebird	Early	.074[a]	.023	.087	.153	.014	.015	.016	.014	.086	.026	.028	.048	.146	.058
	Middle	.256[a]	.103	.128	.325	.029	.021	.029	.018	.154	.053	.202	.058	.128	.056
	Late	.197	.037	.137	.177	.024	.020	.022	.017	.203	.069	.195	.056	.104	.032
	Combined	.166	.048	.116	.216	.021	.018	.022	.011	.118	.025	.118	.029	.127	.052
Vesper Sparrow	Early	.074	.021	.058	.010	.003	.009	.003	.020	.099	.053	.101	.030	.047[a]	.029
	Middle	.094	.062	.078	.270	.023	.024	.025	.025	.390	.139	.216	.045	.080[a]	.019
	Late	.122	.027	.070	.117	.009	.021	.012	.023	.209	.087	.269	.046	.104[a]	.031
	Combined	.097	.024	.068	.164	.011	.019	.009	.011	.204	.054	.207	.020	.074	.036
American Robin	Early	.087	.024	.053	.011	.010	.016	.010	.014	.070	.008	.131	.034	.060	.076
	Middle	.072	.027	.055	.011	.002	.005	.002	.004	.038	.087	.091	.027	.044	.025
	Late	.082	.022	.042	.009	.011	.020	.010	.018	.075	.039	.155	.039	.062	.029
	Combined	.081	.024	.049	.100	.008	.015	.008	.013	.085	.030	.130	.019	.056	.054
Green-tailed Towhee	Early	.161	.038	.088	.150	.009	.012	.010	.013	.142	.050	.031	.033	.036	.028
	Middle	.108	.038	.073	.150	.006	.010	.006	.009	.108	.052	.115	.028	.058	.025
	Late	.194	.036	.105	.150	.032	.049	.010	.013	.202	.097	.176	.047	.066	.042
	Combined	.160	.037	.091	.150	.015	.028	.009	.011	.135	.038	.115	.020	.051	.036

[a] Statistically significant difference at the 95 percent confidence level, using two sample t-test and unequal variance.

Table 3. The coefficient of variation for the five survey techniques.

Year	Technique	Species	Coefficient of Variation (%)
1982	VST	Mountain Bluebird	28.9
		Vesper Sparrow	24.7
		American Robin	29.6
		Green-tailed Towhee	23.1
	FST	Mountain Bluebird	186.2
		Vesper Sparrow	241.2
		American Robin	204.1
		Green-tailed Towhee	164.8
1983	CO	Mountain Bluebird	86.3
		Vesper Sparrow	171.7
		American Robin	188.7
		Green-tailed Towhee	186.3
	PCQ	Mountain Bluebird	75.0
		Vesper Sparrow	160.9
		American Robin	163.4
		Green-tailed Towhee	126.2
	VCP	Mountain Bluebird	20.8
		Vesper Sparrow	26.3
		American Robin	35.4
		Green-tailed Towhee	28.3
	VST	Mountain Bluebird	24.5
		Vesper Sparrow	10.0
		American Robin	14.4
		Green-tailed Towhee	17.2
	FST	Mountain Bluebird	40.9
		Vesper Sparrow	49.1
		American Robin	96.3
		Green-tailed Towhee	69.4

Table 4. Summary statistics for random points and bird species habitat variables on Pole Mountain area.

Point Type		% Total Cover	% Grass Cover	% Forb Cover	% Brush Cover	% Bare	Robel Pole	Canopy Cover	Aspect	Litter Depth	% Litter Cover	Distance to Water	Distance to Road	Distance to Wire	Distance to Pole	Distance to Structure	Distance to Tree	Distance to Perch
RANDOM																		
Early Grazed	$\bar{X}$	66.2	30.5	20.4	15.4	33.7	0.8	5.3	158	0.5	18.9	48	50	58	58	23	30	11
	s	22.3	18.9	18.9	19.9	22.5	1.4	14.0	95	0.8	20.9	29	24	24	24	21	24	15
Middle Grazed	$\bar{X}$	67.4	32.5	20.4	14.6	32.5	0.8	4.0	154	0.5	18.2	46	61	61	60	20	28	10
	s	23.9	21.3	20.6	18.9	24.3	1.3	10.8	102	0.6	19.9	24	22	19	20	19	23	14
Late Grazed	$\bar{X}$	68.5	30.4	19.6	18.6	31.3	1.1	6.3	162	0.6	23.2	44	52	53	55	22	26	7
	s	24.1	19.3	19.0	21.4	24.4	1.8	15.8	101	0.9	25.9	26	24	23	21	19	21	11
Combined	$\bar{X}$	67.3[a]	30.9[a]	20.1	16.4[a]	32.5[a]	0.9[a]	5.4[a]	158	0.5[a]	19.6[a]	46	54[a]	56	57	22[a]	28[a]	9[a]
	s	23.4	19.7	19.3	20.3	23.7	1.5	14.1	99	0.8	22.9	27	24	23	22	21	23	13
BIRDS																		
Mountain Bluebird	$\bar{X}$	62.6[b]	30.0	14.2[b]	18.5[b]	37.3[b]	1.1	3.3[b]	171	1.0[b]	32.6[b]	56	57	48	49	14[b]	13[b]	2[b]
	s	23.3	19.0	14.6	20.8	23.7	1.9	11.3	105	1.2	28.1	23	27	30	29	19	20	6
Green-tailed Towhee	$\bar{X}$	79.1[b]	25.7[b]	11.3[b]	42.3[b]	20.5[b]	3.4[b]	11.8[b]	151	1.7[b]	55.6[b]	44	59	50	51	19[b]	11[b]	1[b]
	s	21.0	18.6	13.8	29.1	21.4	2.9	25.0	88	1.4	29.0	24	16	23	20	20	13	5
Vesper Sparrow	$\bar{X}$	72.3[b]	30.6	14.3[b]	27.6[b]	27.1[b]	1.9[b]	4.4[b]	146	1.0[b]	33.3[b]	49	51	53	52	19[b]	20[b]	4[b]
	s	22.4	18.5	13.7	23.7	22.4	2.3	12.9	99	1.2	27.5	27	22	24	23	21	22	8
American Robin	$\bar{X}$	66.1	31.3	15.9[b]	19.0[b]	32.5	1.3	4.8[b]	172	1.1[b]	39.5[b]	39	62	64	64	11[b]	10[b]	2[b]
	s	25.0	22.4	17.1	18.0	24.5	2.3	14.6	100	1.1	27.6	28	16	17	18	16	16	4
Common Grackle	$\bar{X}$	63.7[b]	35.2	14.1[b]	14.5	35.2	0.6[b]	3.4[b]	175	0.8[b]	26.8[b]	41	71[b]	50	50	23	25	8
	s	19.0	19.9	13.3	16.5	18.5	1.5	9.2	119	1.1	26.1	20	15	26	26	21	23	10
Brewer's Sparrow	$\bar{X}$	74.5[b]	26.6[b]	9.0[b]	39.3[b]	25.0[b]	3.0[b]	17.4[b]	155	1.5[b]	48.3[b]	40	50	56	54	21	23[b]	1[b]
	s	24.4	20.0	12.4	29.6	24.8	2.7	29.2	100	1.2	30.0	26	21	19	22	20	22	4
Horned Lark	$\bar{X}$	58.5[b]	33.4	13.7[b]	11.5	41.4[b]	0.2[b]	1.2[b]	155	0.3	10.7[b]	70	51	50	50	31	52[b]	20[b]
	s	27.2	19.1	15.2	13.8	27.4	0.4	1.2	90	0.3	9.4	-	22	23	23	29	26	20
House Wren	$\bar{X}$	61.9	22.7[b]	10.8[b]	28.5[b]	38.0	1.7	11.9	161	1.3[b]	40.9[b]	37	70	66	65	8[b]	7[b]	0[b]
	s	27.5	18.6	15.2	27.8	27.7	2.5	24.9	90	1.6	32.5	28	20	11	10	13	12	0

a Significant differences exist between the three grazing periods (Kruskal-Wallis Anova, p= .05).
b Significantly different from random habitat points (Kruskal-Wallis Anova, p= .05).

Table 4. Continued.

Point Type		% Total Cover	% Grass Cover	% Forb Cover	% Brush Cover	% Bare	Robel Pole	Canopy Cover	Aspect	Litter Depth	% Litter Cover	Distance to Water	Distance to Road	Distance to Wire	Distance to Pole	Distance to Structure	Distance to Tree	Distance to Perch
Northern Flicker	$\bar{X}$	65.8	32.3	16.4	17.1	34.2	1.2	5.0	168	1.3[b]	42.9[b]	65[b]	50	61	64	14[b]	5[b]	2[b]
	s	20.1	17.0	16.8	15.2	20.4	1.7	16.5	109	1.4	31.9	13	14	19	14	18	9	4
Dark-eyed Junco	$\bar{X}$	68.1	29.3	16.4	22.6[b]	31.8	1.2	3.5	134	1.5[b]	59.7[b]	51	20	49	80	12[b]	4	1[b]
	s	24.8	18.8	16.4	22.4	25.2	1.9	8.6	108	1.2	30.8	26	-	39	-	11	6	3
[c]Brewer's Sparrow	$\bar{X}$	72.3	35.9	21.0	15.6	27.4	1.1	1.7	193	0.7	27.0	28	65	63	63	12	16	8
	s	22.6	20.9	16.5	17.9	23.0	2.0	3.7	111	0.8	27.4	25	7	18	17	17	19	12
Song Sparrow	$\bar{X}$	68.8	34.3	8.4	26.3	31.0	1.1	8.0	142	1.6	56.8	23	40	46	46	16	10	0
	s	29.4	24.2	12.7	22.9	29.7	1.2	15.1	90	1.4	29.8	27	-	35	26	22	20	-
White-crowned Sparrow	$\bar{X}$	92.8	31.4	8.3	53.1	7.0	5.2	4.4	126	1.9	69.6	-	80	41	46	39	7	0
	s	11.5	29.1	10.2	28.6	11.8	3.6	15.4	30	1.3	28.5	-	-	19	18	23	9	0
Chipping Sparrow	$\bar{X}$	66.1	22.9	8.1	35.2	33.7	2.7	8.0	168	0.9	49.3	65	-	30	30	11	10	0
	s	27.2	16.7	11.0	31.1	28.0	3.1	18.2	104	0.6	31.2	21	-	20	20	13	17	-
Clark's Nutcracker	$\bar{X}$	46.7	27.2	4.7	14.8	53.4	0.5	3.7	183	1.5	34.4	43	50	50	50	4	6	2
	s	23.6	20.7	7.4	8.6	23.8	0.7	8.3	112	1.9	34.0	60	-	-	-	6	12	6
Pine Siskin	$\bar{X}$	62.5	27.7	22.5	12.4	37.5	1.0	1.9	119	1.4	37.5	10	50	40	40	10	2	1
	s	27.1	26.2	19.2	12.5	27.4	2.0	2.8	101	0.8	15.5	-	-	13	13	11	3	1
Brown-headed Cowbird	$\bar{X}$	50.7	38.3	7.4	4.9	49.1	0	5.3	130	1.2	32.7	65	75	-	-	29	9	16
	s	34.9	30.2	9.7	8.0	34.6	-	13.0	103	1.4	38.5	35	-	-	-	30	15	30
Broad-tailed Hummingbird	$\bar{X}$	79.9	38.2	17.3	24.7	19.6	2.8	0	152	0.7	34.4	41	45	-	-	29	26	12
	s	20.1	14.0	18.4	19.8	20.6	3.2	-	74	0.8	38.9	47	-	-	-	28	16	14
Mountain Chickadee	$\bar{X}$	62.3	23.5	20.9	18.0	37.6	1.3	11.5	165	1.7	59.4	70	50	50	50	16	1	1
	s	21.5	12.2	9.1	22.7	22.3	1.4	29.7	149	1.0	32.6	-	-	-	-	17	2	2
Red-breasted Nuthatch	$\bar{X}$	46.8	31.2	4.4	11.2	53.6	0	10.8	88	1.1	63.8	10	-	50	50	5	6	0
	s	26.4	21.0	9.8	8.1	26.7	-	21.9	119	0.9	32.8	-	-	-	-	8	13	-
Townsend's Solitaire	$\bar{X}$	53.2	22.2	17.6	13.4	46.8	0.4	0	151	2.4	55.6	-	72	80	80	6	1	0
	s	30.7	22.3	16.7	20.1	31.0	0.5	-	125	2.4	40.5	-	10	-	-	9	3	-
Killdeer	$\bar{X}$	49.3	31.7	17.6	0	36.3	0.8	0	165	0.4	16.0	33	28	50	50	15	[illegible]	13
	s	40.1	30.4	19.3	-	37.1	0.9	[illegible]	109	0.4	17.0	33	10	-	-	9	[illegible]	9

c [illegible]ing birds had too small of sample sizes for Kru[illegible] - Wallis Anova.

Table 5. Results from discriminant analysis between bird species with over 40 observations and the random habitat points.

	Structure Coefficients from direct analysis										
Bird	Percent Grass	Percent Forb	Percent Brush	Percent Open	Robel Pole	Litter Depth	Percent Litter Cover	Distance to Structure	Distance to Tree	Canonical Correlation	Classification Score
Mountain Bluebird	.065 (4)[a]	-.416	.139	.268 (2)	.144	.720 (3)	.742 (1)	.120	-.331	.2207 .2199	89.1 89.2
Green-tailed Towhee	-.141 (4)	-.247 (3)	.653	-.274	.785 (2)	.694 (5)	.824 (1)	-.037	-.175	.4505 .4498	90.5 90.5
Vesper Sparrow	-.020	-.374 (3)	.665	-.284	.755 (1)	.704 (2)	.727	-.029	-.265	.2119 .1998	91.8 91.9
American Robin	.017 (4)	-.200	.119 (2)	-.001	.217	.628	.775 (1)	-.160	-.326 (3)	.2451 .2127	93.5 93.8
Common Grackle	.246	-.357 (2)	-.109 (3)	.127	-.227	.433 (1)	.358	-.059	-.188	.1636 .1129	96.3 96.2
Brewer's Sparrow	-.135	-.356 (3)	.679	-.195	.785 (1)	.701 (2)[b]	.765 (4)	.148 (5)	-.116	.2706 .2683	95.3 95.6
Horned Lark	-.092 (5)	.244	.179	-.276 (3)	.359	.204	.284	-.688 (2)	-.743 (1)	.2103 .2027	96.0 96.0
House Wren	-.340	-.392	.473 (4)	.185 (2)	.410	.782 (1)	.753 (3)	-.107	-.313	.1706 .1664	97.5 97.4
Northern Flicker	.056	-.156 (3)	.027 (2)	.057	.155	.740	.827 (1)	-.151	-.320 (4)	.1654 .1588	97.4 97.7
Dark-eyed Junco	-.044	-.101	.159	-.019 (2)	.100	.610	.909 (1)	-.035	-.206	.2325 .2266	96.9 96.5

a Second line represents the results from the step-wise analysis. The number in parenthesis indicates the order in which the variable was entered the analysis.

b Variable was entered into analysis and then dropped.

Figure 1. The Pole Mountain study area.

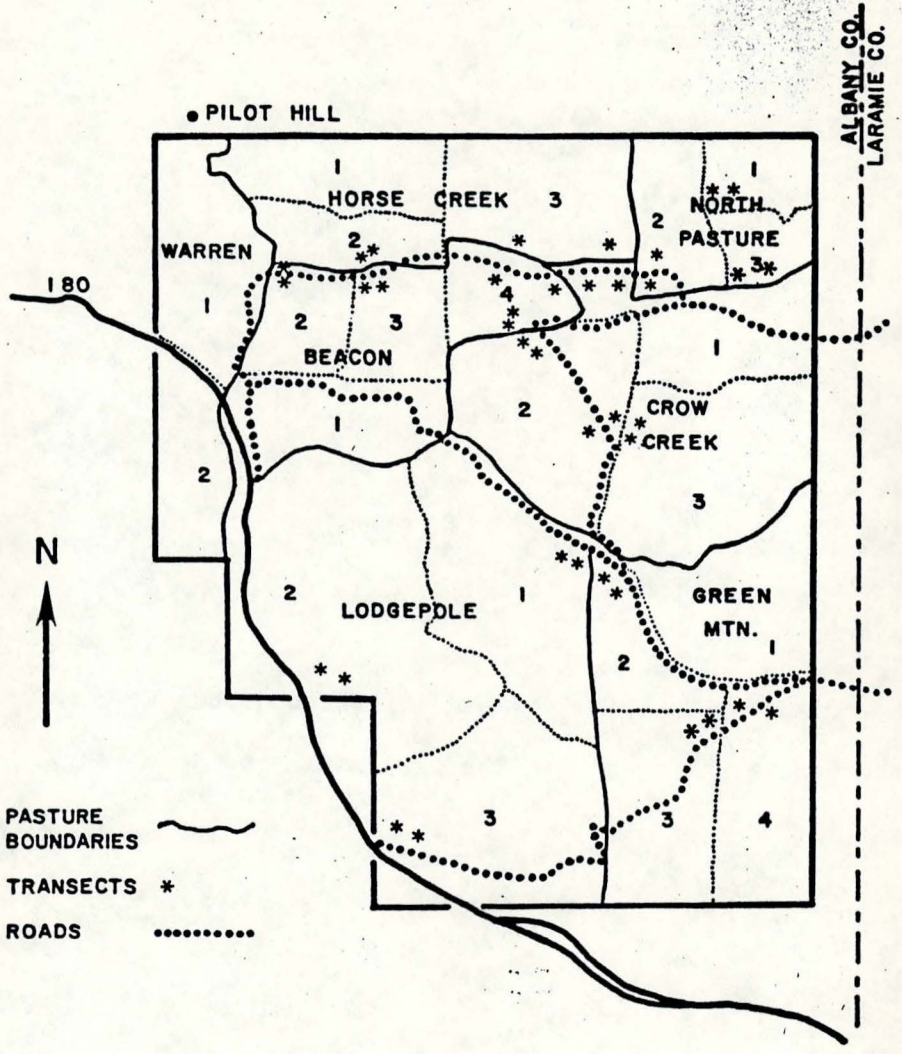

PILOT HILL
ALBANY CO.
LARAMIE CO.
HORSE CREEK
NORTH PASTURE
WARREN
180
BEACON
CROW CREEK
LODGEPOLE
GREEN MTN.
N
PASTURE BOUNDARIES
TRANSECTS
ROADS

Figure 2. The number of birds observed in each successive minute during the preliminary point surveys.

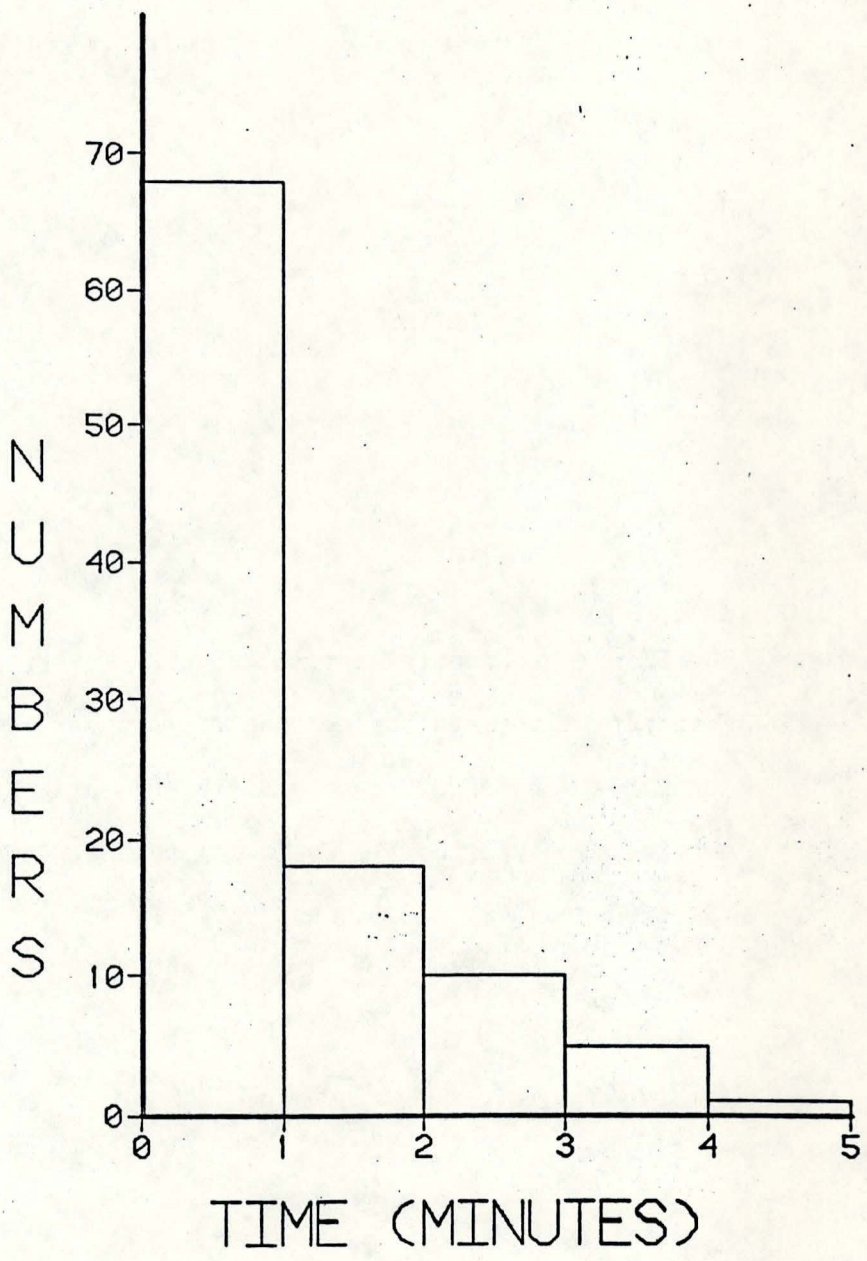

NUMBERS
70
60
50
40
30
20
10
0
0
1
2
3
4
5
TIME (MINUTES)

Figure 3. Density estimates and standard errors for Mountain Bluebirds using the five survey techniques. The estimates were significantly different at the 95 percent confidence level for the following pairs: CO and VCP, CO and VST, PCQ and VCP, and PCQ and VST.

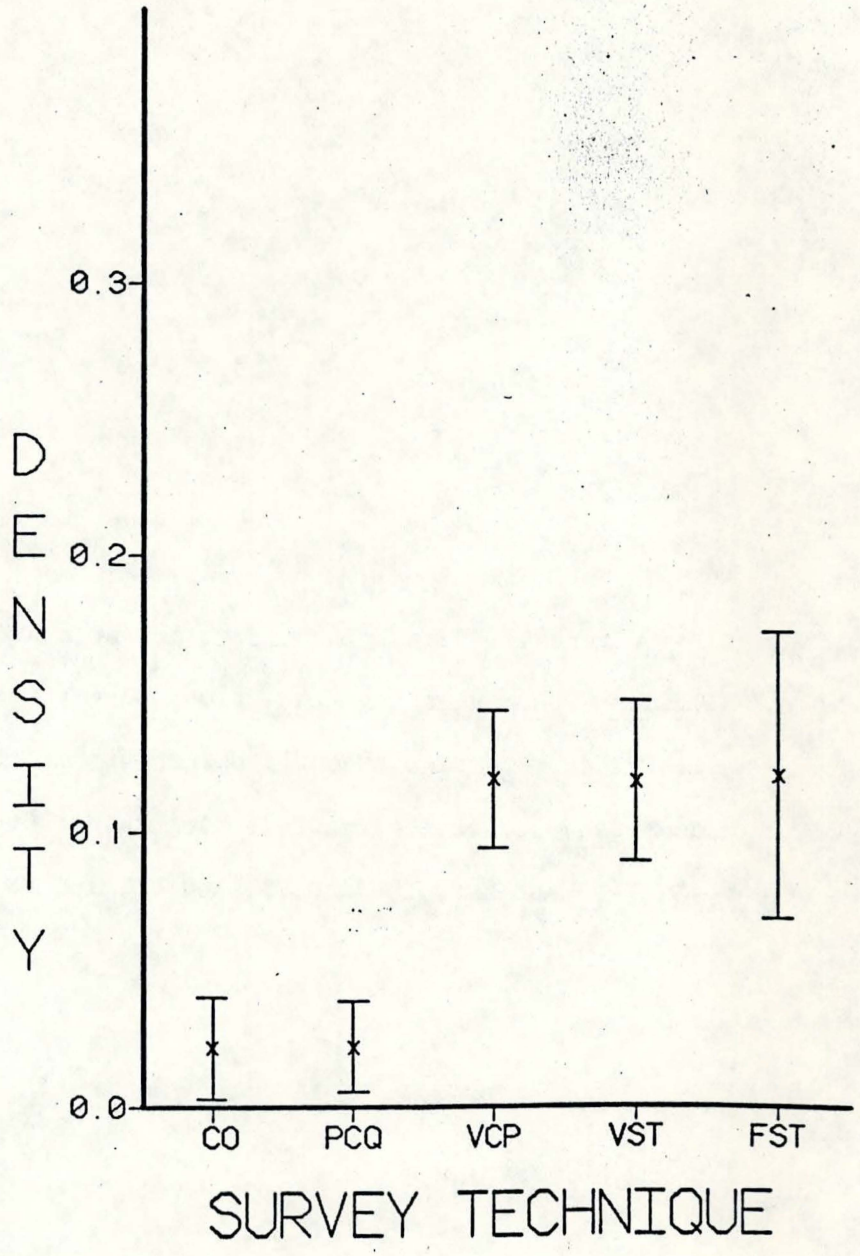

0.3
0.2
0.1
0.0
DENSITY
CO
PCQ
VCP
VST
FST
SURVEY TECHNIQUE

Figure 4. Density estimates and standard errors for the Vesper Sparrow using the five survey techniques. The estimates were significantly different at the 95 percent confidence level for the following pairs: CO and VCP, CO and VST, PCQ and VCP, PCQ and VST and VST and FST.

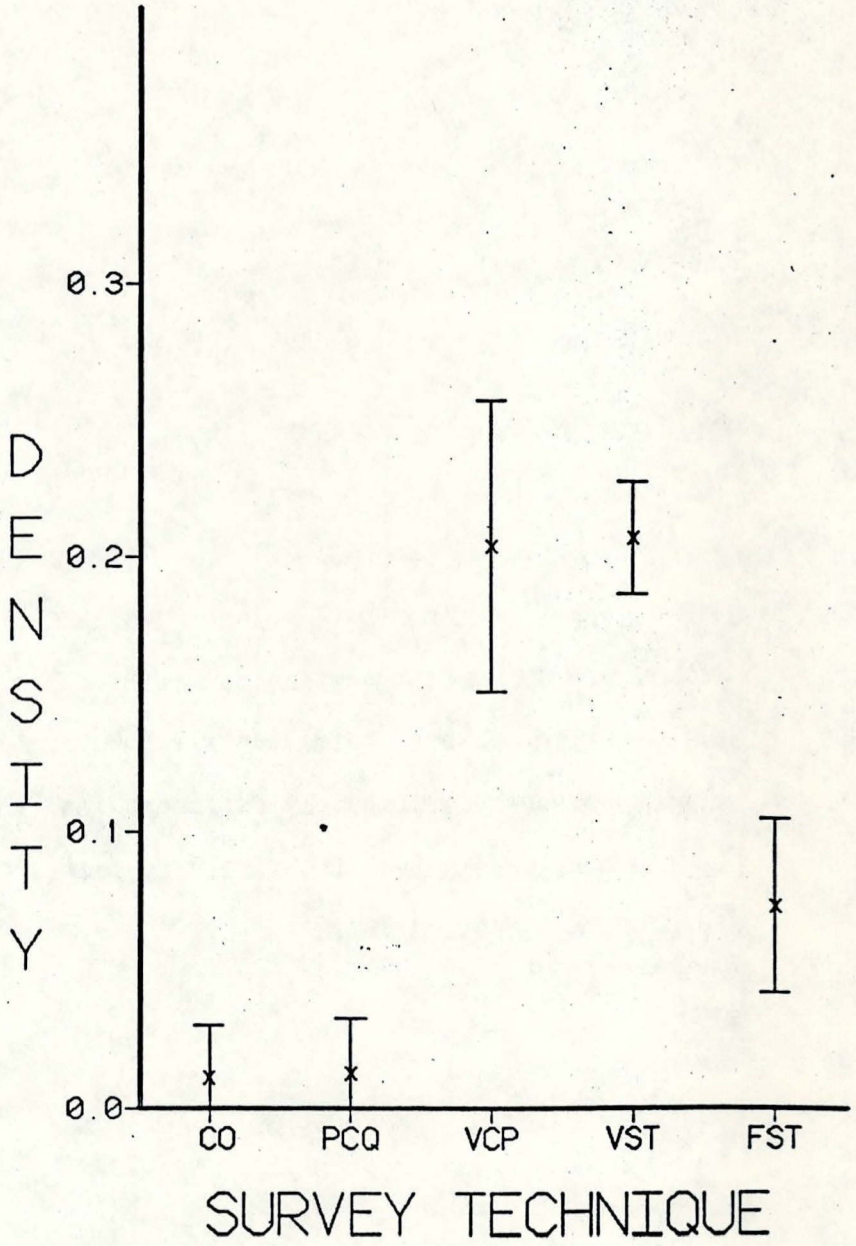

0.3
0.2
0.1
0.0
DENSITY
CO
PCQ
VCP
VST
FST
SURVEY TECHNIQUE

Figure 5. Density estimates and standard errors for the Green-tailed Towhee using the five survey techniques. The estimates were significantly different at the 95 percent confidence level for the following pairs: CO and VST, PCQ and VCP, and PCQ and VST.

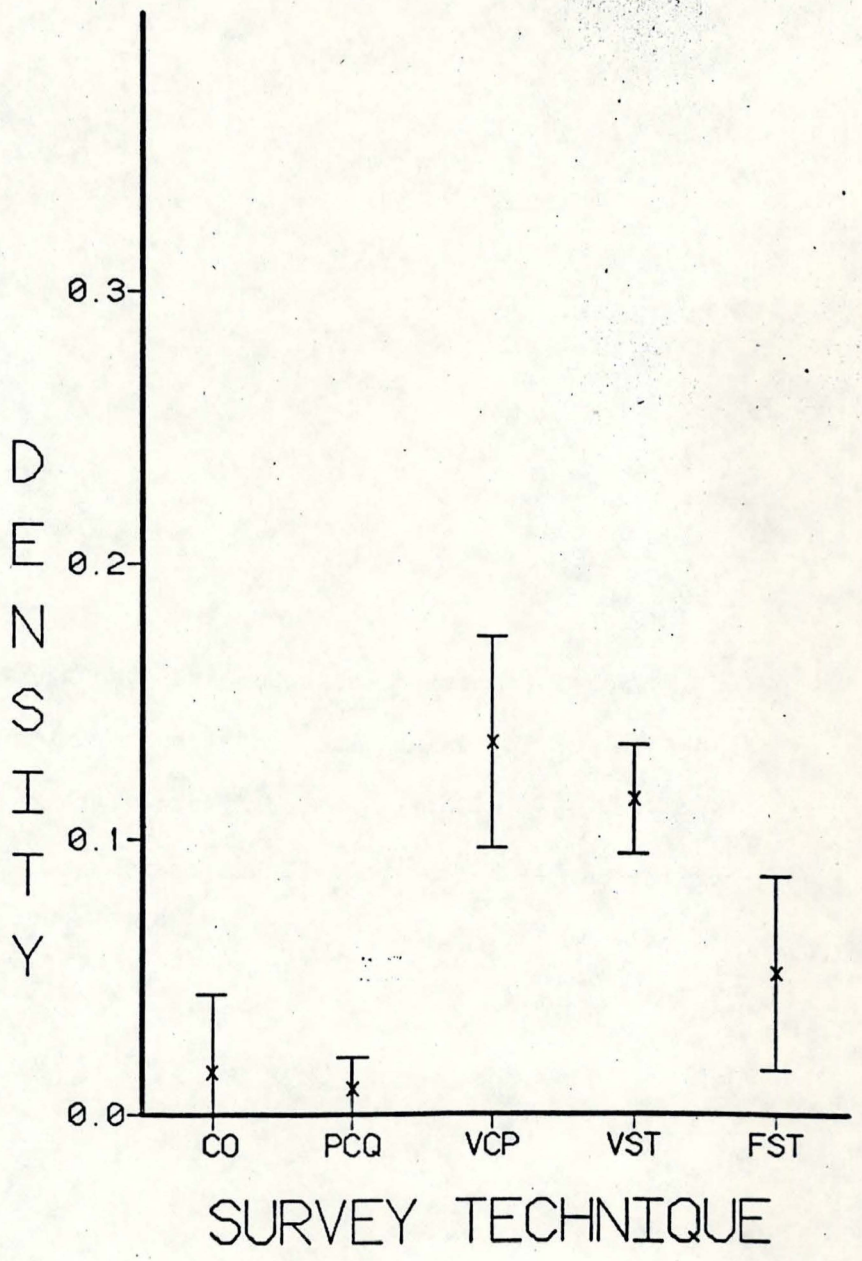

DENSITY
0.3
0.2
0.1
0.0
CO
PCQ
VCP
VST
FST
SURVEY TECHNIQUE

Figure 6. Density estimates and standard errors for the American Robin using the five survey techniques. The estimates were significantly different at the 95 percent confidence level for the following pairs: CO and VST and PCQ and VST.

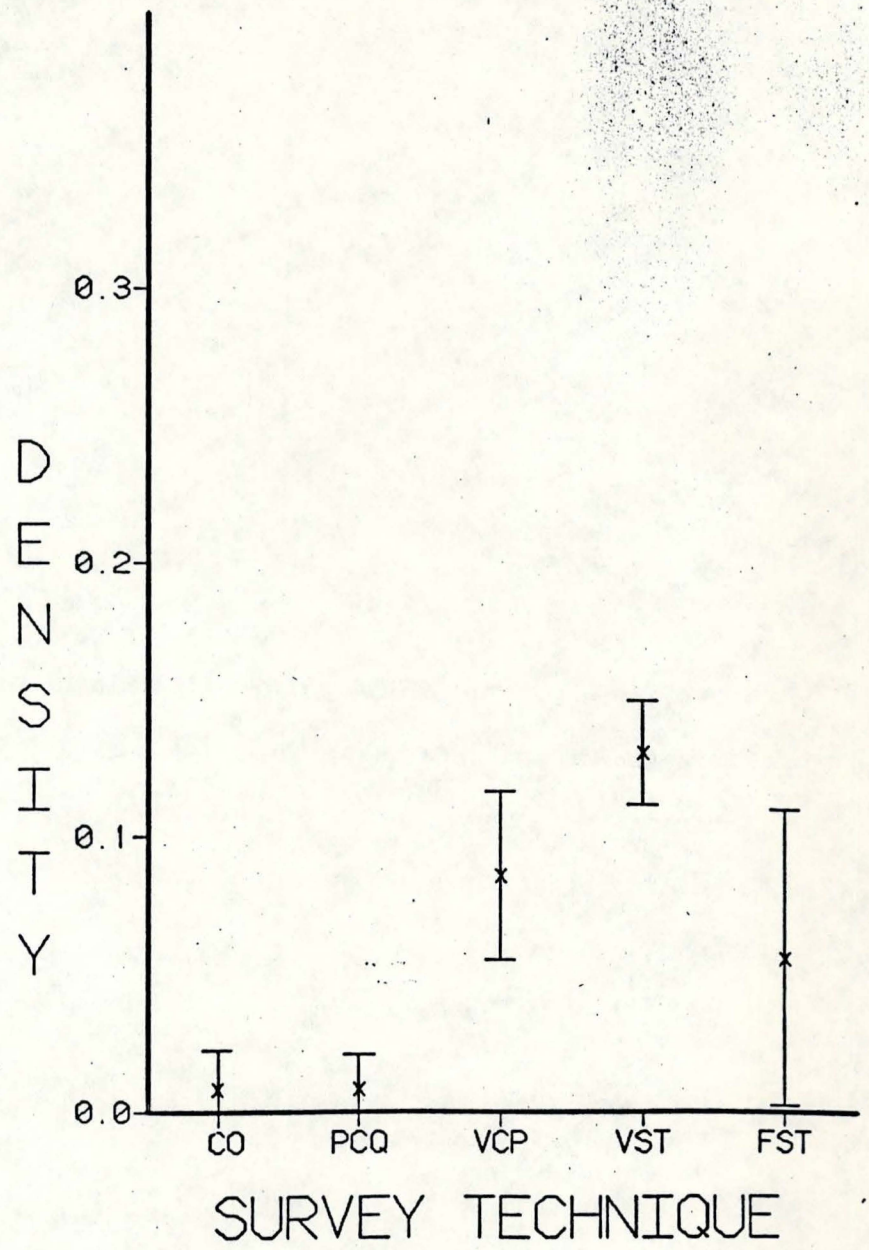

DENSITY
0.3
0.2
0.1
0.0
CO
PCQ
VCP
VST
FST
SURVEY TECHNIQUE

Figure 7. The number of Mountain Bluebirds observed on late grazed pastures using the point survey techniques.

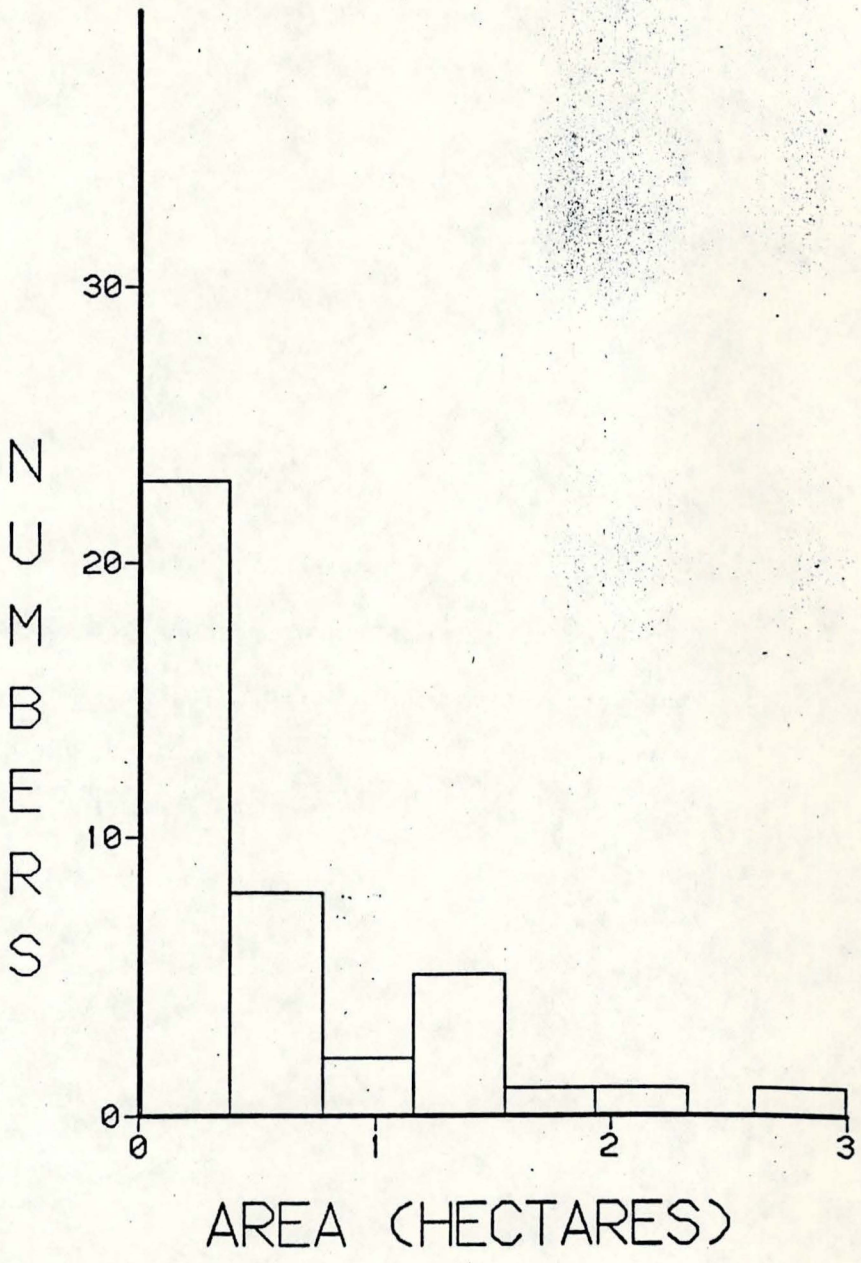
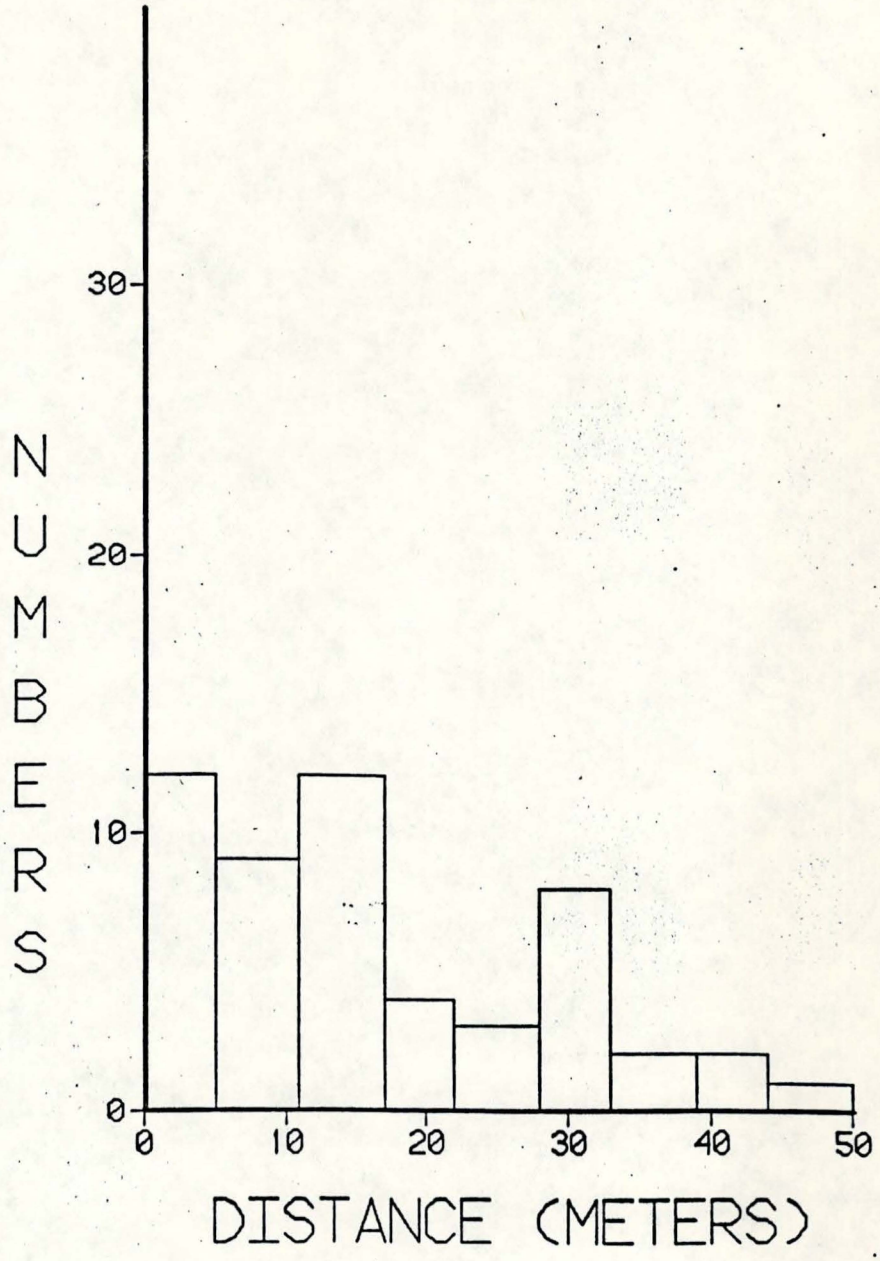

NUMBERS
30
20
10
0
0
1
2
3
AREA (HECTARES)

Figure 8. The number of Mountain Bluebirds observed on the late grazed pastures using the transect suvey techniques.


NUMBERS
30
20
10
0
0
10
20
30
40
50
DISTANCE (METERS)